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(71) Applicant: Sumitomo Rubber Industries Ltd.
Kobe-shi, Hyogo 651 (JP)

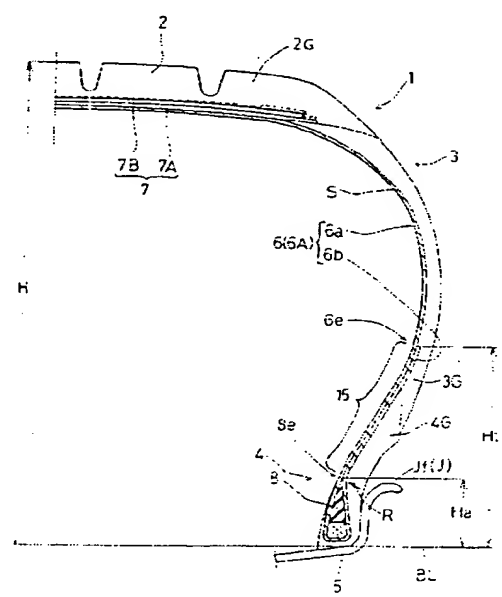
(72) Inventor: Minami, Nobuaki
Shirakawa-shi, Fukushima-ken (JP)

(74) Representative: Stewart, Charles Geoffrey et al
Technical,
Dunlop Tyres Ltd.,
Fort Dunlop
Erdington, Birmingham B24 9QT (GB)

(54) **Tubeless tyre**

(57) A pneumatic tyre having a carcass ply (6A) extending between bead portions (4) and including a topping rubber layer, the topping rubber layer (11i) facing the inside of the tyre being made of a butyl rubber compound containing at least 10 parts by weight of butyl rubber or butyl rubber derivative; and a belt (7) disposed radially outside the carcass in the tread portion (2), comprising at least one ply (7A) of monofilament cords (20) laid at an angle of from 10 to 40 degrees with respect to the circumferential direction of the tyre, each of the monofilament cords consisting of a single filament. The belt (7) further comprises one ply of multifilament cords (7b) or a second ply of monofilament cords (20). The height (Ha) of the bead apex can be reduced into a range of from 10 to 20 mm, and in this case, the carcass ply turnup portion (6b) extends radially outwardly beyond the radially outer end of the bead apex so as to adjoin the carcass ply main portion.

Fig.1



EP 0 985 556 A2

Description

[0001] The present invention relates to a pneumatic tyre, in which the inner liner is eliminated to reduce tyre weight, and the steering stability, ride comfort, durability and the like can be improved.
[0002] In pneumatic tyres used without a tube, the inside of the tyre is covered with an inner liner made of air-impermeable butyl rubber compound disposed on the inside of a carcass.
[0003] Laid-open Japanese patent application Nos. JP-A-6-156007 and JP-A-8-113007 disclose, to reduce the tyre weight, tubeless tyres in which a butyl rubber compound is used for the topping rubber of the carcass, and the inner liner is eliminated.
[0004] However, butyl rubber is low in impact resilience in comparison with diene rubber usually used as the topping rubber, and so when butyl rubber is used the carcass topping rubber, the steering stability, ride comfort and the like deteriorate.
[0005] An object of the present invention is therefore to provide a tubeless tyre, in which a butyl rubber compound is used as the carcass topping rubber, but also the steering stability and ride comfort are good.
[0006] Further, if butyl rubber is used as previously proposed as the carcass topping rubber, a separation failure is liable to occur at the carcass ply turnup end if a stress concentration occurs.
[0007] Another object of the present invention is to provide a tubeless tyre, in which a butyl rubber compound is used as carcass topping rubber, in which such a separation failure is prevented thus improving the durability.
[0008] According to the present invention, a pneumatic tyre comprises a tread portion, a pair of sidewall portions, a pair of bead portions each with a bead core therein, a carcass ply extending between the bead portions and including a topping rubber layer, wherein the topping rubber layer facing the inside of the tyre comprises butyl rubber compound containing at least 10 parts by weight of butyl rubber or butyl rubber derivative, the thickness of the butyl rubber compound measured between the inner surface of the tyre and adjacent cords of the carcass ply being in the range of 0.2 to 1.0 mm, and a belt disposed radially outside the carcass in the tread portion, the belt comprising at least one ply of monofilament cords laid at an angle of from 10 to 40 degrees with respect to the circumferential direction of the tyre, each of the said monofilament cords consisting of a single filament.
[0009] Preferably, the carcass ply is turned up around the bead core in each bead portion so as to form a pair of turnup portions and a main portion therebetween, and a bead apex made of hard rubber is disposed between the turnup portion and main portion. The height of the bead apex is in the range of 10 to 20 mm, and the turnup portion adjoins the main portion of the carcass above the bead apex.
[0010] Embodiments of the present invention will now be described in detail in conjunction with the accompanying drawings:-

Fig.1 is a cross sectional view of an embodiment of the present invention;
Figs. 2(A)-(B) are cross sectional views of a monofilament cord and a multifilament cord, respectively;
Figs. 3(A)-3(C) are schematic sectional views for explaining the thickness of the carcass ply topping rubber;
Fig.4 is a partial sectional view of a part of the carcass in which a turnup portion and main portion of the carcass ply adjoin each other;
Fig. 5 is a cross sectional view of another embodiment of the present invention include an auxiliary cord layer;
Fig. 6 is a cross sectional view showing a modification of the auxiliary cord layer thereof;
Fig.7 is a cross sectional view of still another embodiment of the present invention include an auxiliary cord layer;
Figs.8(A)-8(B) are partial sectional views of the carcass; and
Fig.9 is a cross sectional view of a prior art tyre.

[0011] In the drawings, a pneumatic tyre 1 according to the present invention comprises a tread portion 2, a pair of sidewall portions 3, a pair of axially spaced bead portions 4 each with a bead core 5 therein, a carcass 6 extending between the bead portions 4 through the tread portion 2 and sidewall portions 3, a belt 7 disposed radially outside the carcass 6 in the tread portion 2, and a bead apex 8 made of hard rubber disposed in each of the bead portions 4.
[0012] In this invention, a conventional inner liner disposed along the inside of a carcass is not provided.
[0013] All the illustrated tyres are radial ply tyres for passenger cars.
[0014] If not specifically mentioned, the various sizes and dimensions are measured with the tyre in its normally inflated condition in which the tyre is mounted on a standard rim and inflated to a standard pressure but loaded with no tyre load. Here, the standard rim is the "standard rim" specified in JATMA, the "Measuring Rim" in ETRTO, the "Design Rim" in TRA or the like. The standard pressure is the "maximum air pressure" in JATMA, the "Inflation Pressure" in ETRTO, the maximum pressure given in the "Tyre Load Limits at Various Cold Inflation Pressures" table in TRA or the like. The standard load is the "maximum load capacity" in JATMA, the "Load Capacity" in ETRTO, the maximum value given in the above-mentioned table in TRA or the like. The bead base line BL referred hereinafter is an axial line at a radial height corresponding to the rim diameter of the standard rim.

[0015] The above-mentioned carcass 6 comprises at least one ply 6A of cords 10A arranged radially at an angle of from 75 to 90 degrees with respect to the tyre equator C, and extending between the bead portions 4 through the tread portion 2 and sidewall portions 3, and turned up around the bead core 5 in each bead portion 4 from the axially inside to the outside of the tyre so as to form a pair of turnup portions 6b and a main portion 6a therebetween.
[0016] For the carcass cords 10A, organic fibre cords, e.g. polyester, nylon, rayon, aromatic polyamide, Vinylon and the like are suitably used in the case of passenger car tyres.
[0017] An innermost carcass ply which is the above-mentioned ply 6A in the illustrated examples is rubberised by an inside topping layer 11i and an outside topping layer 11o.
[0018] The inside topping layer 11i is disposed on one side of the innermost carcass ply 6A to face the air cavity of the tyre between one of the bead portions 4 and the other, and the outside topping layer 11o is disposed on the other side of the innermost carcass ply 6A.
[0019] The inside topping layer 11i is made of a butyl rubber compound containing at least 10 parts by weight, preferably at least 30 parts by weight of butyl rubber or butyl rubber derivative with respect to 100 parts by weight of base rubber. Here, butyl rubber means a copolymer (IIR) of isobutylene and a small quantity of isoprene. The butyl rubber derivative is halogenated butyl rubber such as chlorinated butyl rubber and brominated butyl rubber. Usually, the butyl rubber compound further contains reinforcing agents such as carbon black, vulcanising agent, vulcanisation accelerator, softener and the like. Furthermore, the butyl rubber compound may contains diene rubber such as natural rubber (NR), butadiene rubber (BR), styrene-butadiene rubber (SBR) and the like as its base rubber.
[0020] The outside topping layer 11o is made of a non-butyl rubber compound containing at least 90 parts by weight, preferably 100 parts by weight of diene rubber with respect to 100 parts by weight of base rubber.
[0021] The following Table 1 shows an example A of the butyl rubber compound and an example B of the non-butyl rubber compound.

Table 1

(parts by weight)		
Rubber compound	A	B
Base rubber		
Halogenated butyl	30	-
Natural rubber	70	67
Styrene butadiene rubber	-	33
Carbon black	50	57
Oil	-	8.5
Sulfur	3	1.5
Hydrozincite	5	3
Accelerator	1	1
Stearic acid	2	1.5

[0022] In order to obtain a sufficient air sealing effect, the minimum thickness Ti of the inside topping rubber 11o measured from its surface to the carcass cords 10A is set in the range of 0.2 to 1.0 mm, preferably 0.3 to 0.8 mm. If the minimum thickness Ti is less than 0.2 mm, the necessary air tightness can not be obtained. If the minimum thickness Ti is more then 1.0 mm, there is deterioration of steering stability and ride comfort, and the tyre weight increases.
[0023] The boundary E between the inside topping layer 11i and the outside topping layer 11o may be positioned on a centre line N linking the centres of the cords 10A as shown in Fig.3(A) or outside the centre line N as shown in Fig. 3(B) or inside the centre line N as shown in Fig.3(C). However, from a point of view of balance between the steering stability and ride comfort and the adhesiveness to the carcass cords, the maximum rubber thickness T of the inside topping layer measured from its surface to the boundary E is preferably not more than Ti+0.5D and not more than 1.5 mm. For example, the thickness T is 0.5 to 1.0 mm.
[0024] To define the above-mentioned tread portion 2, sidewall portions 3 and bead portions 4, a tread rubber 2G, sidewall rubber 3G and bead rubber (clinch rubber) 4G are disposed outside the carcass 6. For these materials, conventional rubber compounds which are not the above-mentioned butyl rubber compound can be used.
[0025] The above-mentioned belt comprises a breaker 7 and optionally a band or bandage wound thereon.
[0026] The breaker 7 comprises at least one ply of monofilament cords 20 and optionally a ply of multifilament cords

30, wherein each ply extends across at least 80% of the tread width.

[0027] The monofilament cord 20 is composed of a single steel filament as shown in Fig.2(A) . The multifilament cord 30 is composed of at least three steel filaments 31 twisted together as shown in Fig.2(B). These filaments 20 and 31 also may be made of organic materials, e.g. nylon, rayon, polyester, aramid and the like.

[0028] Usually, the breaker 7 comprises two crossed plies of parallel cords laid at an angle of 10 to 40 degrees with respect to the circumferential direction of the tyre, and at least one of the two cross plies is the above-mentioned monofilament cord ply.

[0029] The diameter D1 of the monofilament cord 20 is preferably in the range of from 0.35 to 0.55 mm.

[0030] The multifilament cord 30 comprises three steel filaments 31 each having a diameter D2 in the range of from 0.20 to 0.40 mm. And the diameter D3 of the multifilament cord 30 is in the range of from 0.50 to 0.70 mm.

[0031] The sectional area 20S of the monofilament cord 20 is set in the range of from 0.68 to 0.88 times the total sectional area 31S of the steel filaments 31 of the multifilament cord 30.

[0032] For example, when the multifilament cord 30 has a 1X3/0.27 structure (total sectional area = 0.1717 sq.mm), the sectional area 20S of the monofilament cord 20 is set in the range of from 0.117 to 0.151 sq.mm. Thus, the diameter D1 of the monofilament cord 20 is set in the range of from 0.39 to 0.44 mm (in this example 0.42 mm for 1X3/0.27).

[0033] The cord count N of the monofilament cord ply and the multifilament cord ply is in the range of from 33 to 47 (cords/ 5 cm).

[0034] The band (not shown) is disposed radially outside the breaker and is composed of spiral windings of at least one cord or a strip containing parallel cords. The cord angle is less than 10 degrees, usually substantially 0 degrees with respect to the circumferential direction of the tyre.

[0035] The above-explained structure can be applied not only to passenger car tyres but also motorcycle tyres, light truck tyres and the like.

[0036] Table 2 shows results of comparison tests in which all the test tyres had the same structure except for the belt structure, carcass ply topping rubber and inner liner.

Air tightness test:

[0037] The tyre, mounted on a standard rim and inflated to normal pressure, was put in a 80 deg. C hot chamber for 15 days. Then, the loss of pressure was measured and the inverse number thereof is indicated by an index based on Prior art tyre being 100. The larger the index, the better the air tightness.

Production efficiency test:

[0038] The time required to make a raw tyre was measured. The results are indicated by an index based on the Prior Art tyre being 100. The smaller the index, the better the production efficiency.

Steering stability and Ride comfort test:

[0039] A test car provided on all the four wheels with test tyres was run on a test course, and the steering stability (steering response, rigidity, grip, transient side force, linearity, critical comering speed) was evaluated based on ten ranks by the driver's feeling. The higher the rank, the better the steering stability. Further, the test car was run on a bumpy road, stone-paved road and gravelled road on a tyre test course and the ride comfort (harshness, pushing-up, damping) was evaluated into ten ranks by the driver's feeling The higher the rank, the better the ride comfort.

Tyre weight:

[0040] The weight of the type was measured and indicated by an index based on Prior art tyre being 100. The smaller the index, the lighter the weight.

Table 2

Tyre	Ex.A1	Ex.A2	Ex.A3	Ref.A1	Ref.A2	Ref.A3	Prior
Inner liner	none	None	none	none	present	present	present
Carcass	1 ply	1 ply	1 ply	1 ply	1 ply	1 ply	1 ply
Cord angle (deg.)	90	90	90	90	90	90	90
Cord	polyester 1100dtex/2	Polyester 1100dtex/2	Polyester 1100dtex/2	polyester 1100dtex/2	polyester 1100dtex/2	polyester 1100dtex/2	polyester 1100dtex/2
Cord count (/5cm)	61	61	61	61	61	61	61
Topping Rubber							
Inside	A	A	A	A	B	B	B
Outside	B	B	B	B	B	B	B
Thickness Ti (mm)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Belt *	2 plies	2 plies	2 plies	2 plies	2 plies	2 plies	2 plies
Inner ply	multi	Mono	mono	multi	mono	mono	multi
Cord	steel 1X3/0.27	Steel 1X1/0.42	steel 1X1/0 42	steel 1X3/0.27	steel 1X1/0.42	steel 1X1/0.42	steel 1X3/0.27
Cord count (/5cm)	40	40	40	40	40	40	40
Outer ply	mono	Multi	mono	multi	mono	mono	multi
Cord	steel 1X1/0.42	Steel 1X3/0.27	steel 1X1/0.42	steel 1X3/0.27	steel 1X1/0 42	steel 1X1/0.42	steel 1X3/0.27
Cord count (/5cm)	40	40	40	40	40	40	40
Tyre weight	92	92	91	93	98	98	100
Air tightness	100	100	100	100	100	100	100

Table 2 (continued)

Tyre	Ex.A1	Ex.A2	Ex.A3	Ref.A1	Ref.A2	Ref.A3	Prior
Production efficiency	90	90	90	90	100	100	100
Steering stability	7	6.5	6.5	5	7	7	6
Ride comfort	6.5	7	6.5	7	5	5	6

Note: Belt cord angles are plus/minus 24 degrees with respect to the tyre equator.
Tyre size: 195/65R14, Rim size: 6JJX14 (standard rim), Tyre pressure: 200 kpa (normal)
Test car: 2000cc FF passenger car

[0041] Based on the above-explained basic structure, various modifications can be made as follows.

* Small Bead Apex

[0042] In order to reduce further the tyre weight, it is possible to reduce the volume of the above-mentioned bead apex 8 as shown in Fig.1. This structure can be applied to not only passenger car tyres but also motorcycle tyres, light-truck tyres and the like. In this case, it is effective to remarkably reduce the bead apex height Ha in comparison with usual height so that the height Ha is roughly the same as that of the flange Jf of the standard wheelrim J for the tyre. The height Ha is then in the range of from 10 to 20 mm, preferably 13 to 17 mm from the bead base line BL.

[0043] The bead apex 8 is made of relatively hard rubber having a JIS-A hardness of from 65 to 95 degrees, preferably 70 to 90 degrees, and tapers radially outwardly from the bead core.

[0044] Further, the height Ht of the carcass ply turnup portion 6b must be more than the height Ha of the bead apex 8 so as to form an adjoining part 15 in which the carcass ply turnup portion 6b and main portion 6a adjoin each other. This structure helps to improve the steering stability and ride comfort.

[0045] The height Hb of the radially outer end 6e of the turnup portion 6b is set in the range of from 0.3 to 0.7 times, preferably 0.40 to 0.55 times the tyre section height H, each from the bead base line BL.

[0046] Near the outer end 8e of the bead apex 8, the turnup portion 6b is curved concavely along the axially outer side of the bead apex, and the radius R of curvature is in the range of from 5 to 15 mm, preferably 8 to 12 mm, whereby a separation due to residual air can be prevented.

[0047] In the adjoining part 15, as shown in Fig. 4, the rubber thickness Tb between the cords in the turnup portion 6b and the adjacent cords in the main portion 6a is in the range of from 0.3 to 0.8 mm.

[0048] If the thickness Tb is less than 0.3 mm, a ply separation failure is liable to occur. If the thickness Tb is more than 0.8 mm, the tyre weight is increased.

[0049] If the bead apex height Ha is less than 10 mm, it is difficult to make such a structure. If the bead apex height Ha is more than 20 mm, the stress in the turnup portion 6b increases and a separation therefrom is liable to occur.

[0050] If the height Ht is less than 0.3 times the height H, the lateral stiffness becomes insufficient, and the steering stability greatly deteriorates. If the height Ht is more than 0.7 times the height H, ride comfort is lowered.

[0051] Table 3 shows results of comparison tests, wherein test tyres had the same structure except for the bead apex, carcass ply topping rubber and inner liner.

Table 3

Tyre	Ex.B1	Ex.B2	Ref.B1	Prior
Inner liner	None	None	present	present
Carcass	1 ply	1 ply	1 ply	1 ply
Cord	1100dtex/2	1100dtex/2	1100dtex/2	1100dtex/2
Cord count/5cm	61	61	61	61
Topping rubber				
Inside	A	A	B	B
Outside	B	B	B	B
Thickness Ta (mm)	0.3	0.3	-	-
Thickness Tb (mm)	0.6	0.6	0.4	0.4
Turnup height hb (mm)	61 (0.5H)	61 (0.5H)	61 (0.5H)	61 (0.5H)
Radius of curvature R (mm)	10	75	10	75
Tyre section height H (mm)	122.5	122.5	122.5	122.5
Bead apex height ha (mm)	15	40	15	40
Tyre weight	90	93	97	100
Air tightness	100	100	100	100
Production efficiency	85	90	95	100
Steering stability	6	7	5	6
Ride comfort	6.5	5.5	7	6
Tyre size: 175/70R13 Rim size; 5JJX13 (standard rim) Test car: 1600cc FF passenger car				

Auxiliary Cord Layer in Upper Sidewall

[0052] Figs. 5 and 6 show other modifications, wherein the carcass 6 is composed of a single ply 6A, an auxiliary cord layer 13 is disposed outside the carcass 6, and the height of the carcass ply turnup portion 6b is decreased, but the height of the bead apex 8 is again increased. This structure may be applied to motorcycle tyres, light truck tyres and the like in addition to passenger car tyres.

[0053] The bead apex 8 is made of hard rubber having a JIS-A hardness of from 65 to 95 degrees, preferably 70 to 90 degrees.

[0054] The height Ha of the radially outer end 8e of the bead apex 8 is 0.15 to 0.55 times, preferably 0.15 to 0.30 times the tyre section height H.

[0055] The radially outer end 6e of the turnup portion 6b is positioned radially inwards of the radially outer end 8e of the bead apex 8, and the radial distance h between the ends 6e and 8e is at least 5 mm, preferably not less than 10 mm, more preferably in the range of from 10 to 25 mm.

[0056] The bead apex rubber 8 is relatively hard and relatively thick in the lower part. Therefore, its bending deformation is relatively small. Thus, by disposing the turnup end 6e beside the bead apex 8, a separation failure can be prevented and the durability is improved.

[0057] The auxiliary cord layer 13 is composed of a single ply of radially arranged cords, and both sides thereof are rubberised with the above-mentioned non-butyl rubber compound.

[0058] The auxiliary cord layer 13 has a radially inner end 13e in each of the sidewall portions 3. The radially inner end 13e is located at a position radially outwardly spaced apart from the radially outer end 8e of the bead apex, and the radial distance S therebetween is in the range of of from 10 to 15 mm. The auxiliary cord layer 13 extends at least from each of the radially inner ends 13e to a position beneath the belt 7. If not, the steering stability deteriorates. When the carcass cord angle is 90 degrees with respect to the tyre equator, the cord angle of the auxiliary cord layer is also set at 90 degrees. When the carcass cord angle is not 90 degrees, the cords of the auxiliary cord layer are arranged at an angle numerically the same as or similar to the carcass cord angle so as to cross the carcass cords. Preferably, the auxiliary cord layer 13 is the same as the carcass ply in respect of the material, sizes and construction of the cord and the cord count in the ply.

[0059] Fig.5 shows an example of an auxiliary cord layer 13 which extends continuously from one of the sidewall portions 3 to the other. In this case, the steering stability is still further improved.

[0060] Fig.6 shows another example of the auxiliary cord layer 13 which breaks under the belt 7, thus it is made up of two axially spaced parts 13B. In this case, the tyre weight is further decreased.

[0061] Table 4 shows results of comparison tests, wherein test tyres had the same structure except for the bead apex, carcass ply topping rubber and inner liner.

Table 4

Tyre	Ex.C1	Ex.C2	Ex.C3	Ex.C4	Prior	Prior 2
Inner liner	none	none	None	none	Present	present
Carcass	1 ply	1 ply	1 ply	1 ply	1 ply	2 plies
Topping rubber						
Inside	A	A	A	A	B	B
Outside	B	B	B	B	B	B
Turnup end position *	inside	inside	Outside	inside	Outside	outside
Auxiliary ply	Fig.5	Fig.6	None	none	None	none
Tyre weight	86	83	83	80	90	100
Air tightness	100	100	98	98	98	100
Production efficiency	88	100	77	77	88	100
Steering stability	6	5.5	5	4	5	6
Ride comfort	6.5	6.5	6.5	7	6.5	6

Note: radially "outside" or "inside" of the radially outer end of the bead apex
Tyre size: 195/65R14, Rim size: 6JJX14 (standard rim)
Inner pressure: 200 kPa (normal), Test car: 2000cc FF passenger car

Auxiliary Cord Layer in Lower Sidewall

[0062] Fig.7 shows a further modification, wherein the carcass 6 is composed of a single ply 6A, and a bead rein-

forcing cord layer 9 is disposed between the carcass ply turnup portion 6b and the bead apex 8. This structure may be applied to motorcycle tyres, light truck tyres and the like in addition to passenger car tyres.

[0063] The bead apex 8 has a JIS-A hardness of from 65 to 95 degrees, more preferably 70 to 90 degrees.

[0064] The bead reinforcing cord layer 9 is made of cords laid at an angle of 10 to 60 degrees (in this example 10 to 30 degrees) with respect to the circumferential direction of the tyre, and both sides thereof are rubberised with the above-mentioned non-butyl rubber. For such cords, steel cords and high modulus organic cords such as aromatic polyamide and the like are preferably used.

[0065] The radially inner end 9d of the bead reinforcing cord layer 9 is preferably, positioned at a distance L of not more than 7 mm from the radially outside of the bead core 5.

[0066] The height Hs of the bead reinforcing cord layer 9 is more than the height Ha of the bead apex 8, but less than the height Ht of the carcass ply turnup portion 6b. The height Ha is set in the range of from 0.20 to 0.40 times the tyre section height H. The height Hs is set in the range of from 0.30 to 0.50 times the tyre section height H. The height Ht is set in the range of from 0.40 to 0.60 times the tyre section height H, and preferably, the difference (Hs-Ha) is not less than 10 mm and the difference (Ht-Hs) is not less than 5 mm. If not, due to stress concentration, durability is liable to deteriorate. It is especially preferable that the difference (Hs-Ha) and the difference (Ht-Hs) are substantially the same value of 0.1 to 0.15 times the tyre section height H. Here, each height is measured radially from the bead base line BL.

[0067] As shown in Fig.8(A), in a first region Y1 between the outer ends 8e and 9e of the bead apex 8 and bead reinforcing cord layer 9, respectively, the rubber thickness T1 between the cords in the bead reinforcing cord layer 9 and the adjacent carcass cords 10A in the turnup portion 6b is set in the range of from 0.2 to 0.5 mm.

[0068] As shown in Fig.8(B), in a second region Y2 between the outer ends 9e and 6e of the bead reinforcing cord layer 9 and carcass ply turnup portion 6b, respectively, the rubber thickness T2 between the carcass cords 10A in the turnup portion 6b and the carcass cords 10A in the carcass main portion 6a is set in the range of from 0.3 to 0.8 mm.

[0069] Table 5 shows results of comparison tests in which test tyres all had the same structure except for the bead reinforcing cord layer, carcass ply topping rubber and inner liner.

Table 5

Tyre	Ex.D1	Ex.D2	Ref.D1	Prior
Inner liner	None	none	present	present
Carcass	1 ply	1 ply	1 ply	1 ply
Cord	Polyester 1100dtex/2	Polyester 1100dtex/2	polyester 1100dtex/2	polyester 1100dtex/2
Cord count/5cm	60	60	60	60
Topping rubber				
Inside	A	A	B	B
Outside	B	B	B	B
Thickness Ti (mm)	0.3	0.3	-	-
Bead reinforcing cord	present	none	present	none
Cord	steel (1X3X0.27)	-	steel (1X3X0.27)	-
Cord angle (deg.)	21	-	21	-
Cord count/5cm	40	-	40	-
Height Ha (mm)	30	30	30	30
Height Hs (mm)	55	-	55	-
Height Ht (mm)	70	70	70	70
Height H0 (mm)	127	127	127	127
Thickness T1 (mm)	0.4	-	0.4	-
Thickness T2 (mm)	0.6		0.6	
Tyre weight	97	93	104	100
Air tightness	100	100	100	100
Production efficiency	93	90	103	100
Steering stability	7	5.5	7.5	6

Table 5 (continued)

Tyre	Ex.D1	Ex.D2	Ref.D1	Prior
Ride comfort	6	6.5	5.5	6
Tyre size: 195/65R14, Wheelrim size: 6JJX14 (standard rim) Inner pressure: 200 kPa (normal), Test car: 2000cc FF passenger car				

As described above, in the tubeless tyres according to the present invention, to remove a conventional inner liner, the topping rubber layer on the side of the innermost carcass ply is made of a butyl rubber compound having a specific thickness, and at least one of the belt plies is made of monofilament cords. As a result the steering stability, ride comfort and the like are improved. Further, by employing the small bead apex and providing the carcass ply adjoining part, the tyre weight can be further decreased and a decrease in the durability due to carcass ply separation can be prevented.

Claims

1. A pneumatic tyre comprising a tread portion (2), a pair of sidewall portions (3), a pair of bead portions (4) each with a bead core (5) therein, a carcass ply (6A) extending between the bead portions (4) characterised by a topping rubber layer (11i) facing the inside of the tyre and made of a butyl rubber compound containing at least 10 parts by weight of butyl rubber or butyl rubber derivative, the thickness (Ti) of the butyl rubber compound measured between the inner surface of the tyre and adjacent cords of the carcass ply (6A) being in the range of 0.2 to 1.0 mm and a belt (7) disposed radially outside the carcass in the tread portion (2), said belt (7) comprising at least one ply of monofilament cords (20) laid at an angle of from 10 to 40 degrees with respect to the circumferential direction of the tyre, each said monofilament cord (20) consisting of a single filament.

2. A pneumatic tyre according to claim 1, characterised by two plies of monofilament cords (20).

3. A pneumatic tyre according to claim 1 or 2, characterised in that said belt (7) further comprises one ply (7B) of multifilament cords (30) laid at an angle of from 10 to 40 degrees with respect to the circumferential direction of the tyre.

4. A pneumatic tyre according to claim 1, 2 or 3, characterised in that said carcass ply (6A) is tumed up around the bead core (5) in each said bead portion (4) to form a pair of turnup portions (6b) and a main portion (6a) therebetween, each said bead portion (4) is provided between the tumup portion (6b) and main portion (6a) with a bead apex (8), the bead apex (8) extending radially outwardly from the bead core (5), and the height (Ha) of the radially outer end (8e) thereof is 10 to 20 mm from a bead base line (BL), said tumup portion (6b) extending radially outwardly beyond the radially outer end (8e) of the bead apex (8) so as to adjoin the main portion (6a), and the thickness (Tb) of rubber between the cords in the turnup portion (6b) and the cords in the main portion (6a) is 0.3 to 0.8 mm.

5. A pneumatic tyre according to claim 1, 2, 3 or 4, characterised in that an auxiliary cord layer (13) is provided which is rubberised with a non-butyl topping rubber compound and is disposed outside the carcass ply (6A), the auxiliary cord layer (13) having a radially inner end (13e) in each said sidewall portion (3), the radially inner end (13e) being spaced radially outwardly apart from the radially outer end (8e) of the bead apex (8) by a distance (S) of 10 to 15 mm and the auxiliary cord layer (13) extends radially outwardly from each said radially inner end (8e) at least to a position beneath the belt (7).

6. A pneumatic tyre according to claim 5, characterised in that the height (Ha) of the radially outer end (8e) of the bead apex (8) is 0.15 to 0.55 times the tyre section height (H), and the radial distance between the radially outer end (8a) of the bead apex (8e) and the end of the turned up portion (6b) is not less than 5 mm.

7. A pneumatic tyre according to claim 5 or 6, characterised in that the auxiliary cord layer (13) extends continuously between the radially inner ends (13e) thereof.

8. A pneumatic tyre according to claim 5 or 6, characterised in that the auxiliary cord layer (13) breaks in the tread portion beneath the belt (7).

9. A pneumatic tyre according to claim 1, 2 or 3, characterised in that said carcass ply (6A) is turned up around the bead core (5) in each said bead portion (4) to form a pair of turnup portions (6b) and a main portion (6a) therebetween, each said bead portion (4) is provided between tne turnup portion (6b) and main portion (6a) with a bead apex (8) extending radially outwardly from the bead core (5), a bead reinforcing cord layer (9) is disposed between the bead apex (8) and turnup portion (6b) in each said bead portion (4), the height (Hs) of the radially outer end (9e) of the bead reinforcing cord layer (9) is more than the height (Ha) of the radially outer end (8e) of the bead apex (8), but less than the height (Ht) or the radially outer end (6e) of the turnup portion (6b), in a first region (Y1) between the end (8e) and end (9e), the thickness (T1) of rubber between the cords in the turnup portion (6b) and the cords in the bead reinforcing cord layer (9) is 0.2 to 0.5mm, in a second region (Y2) between the end (9e) and end (6e), the thickness (T2) of rubber between the cords in the main portion (6a) and the cords in the turnup portion (6b) is 0.3 to 0.8 mm.

10. A pneumatic tyre according to claim 9, characterised in that the height (Ht) of the turnup portion is 0.4 to 0.60 times the tyre section height, the height (Hs) of the bead reinforcing cord layer is 0.3 to 0.50 times the tyre section height, the height (Ha) of the bead apex (8) is 0.20 to 0.40 times the tyre section height, the difference (Hs-Ha) between the height (Ha) and height (Hs) is not less than 10 mmm and the difference (Ht-Hs) between the height (Hs) and height (Ht) is not less than 5 mm.

11. A pneumatic tyre according to claim 9, characterised in that the difference (Hs-Ha) and difference (Ht-Hs) are the substantially same values of 0.1 to 0.15 times the tyre section height (H).

Fig.1

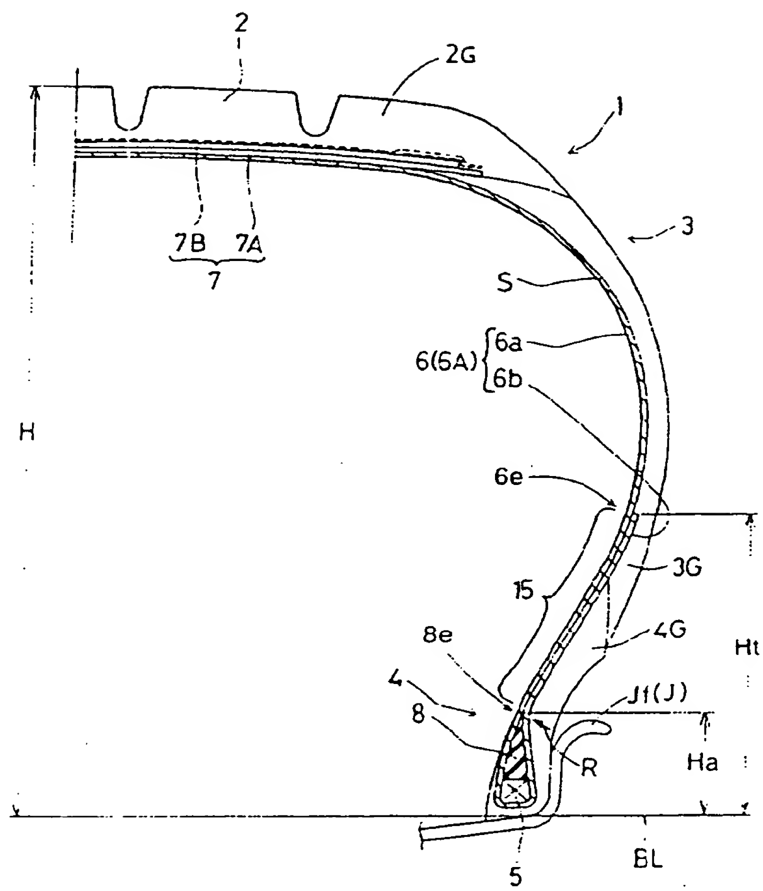


Fig.2(A)

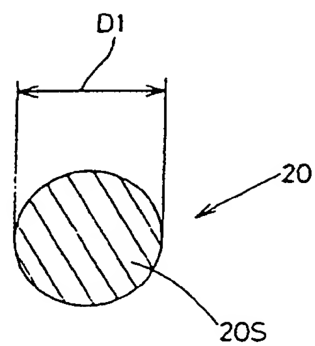


Fig.2(B)

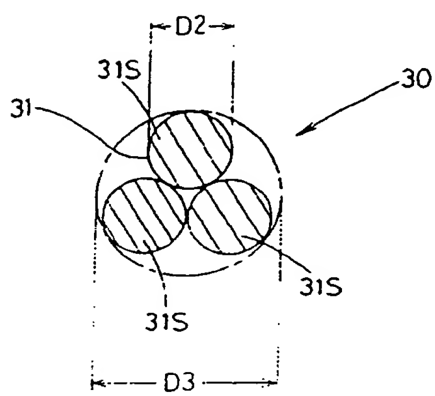


Fig.3(A)

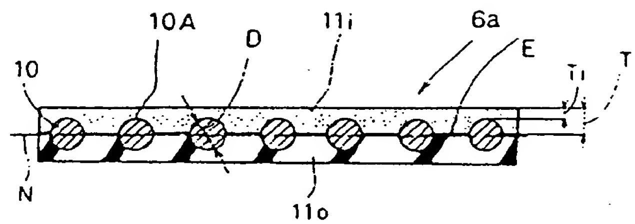


Fig.3(B)

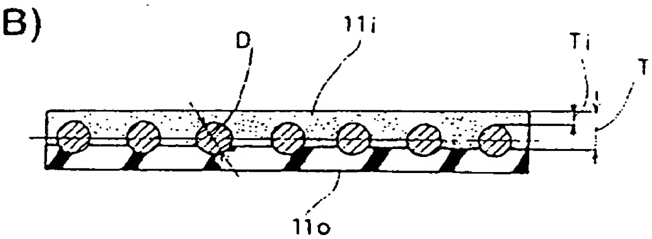


Fig.3(C)

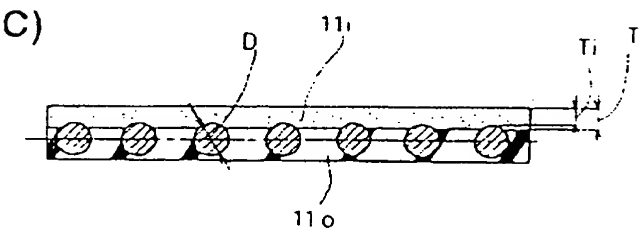


Fig.4

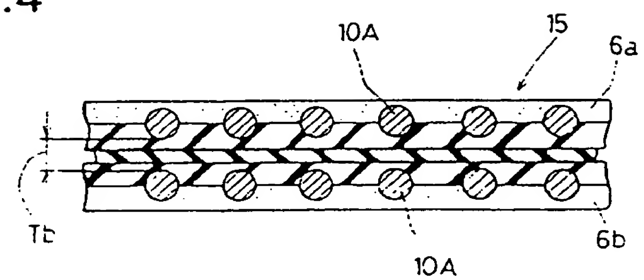


Fig.8(A)

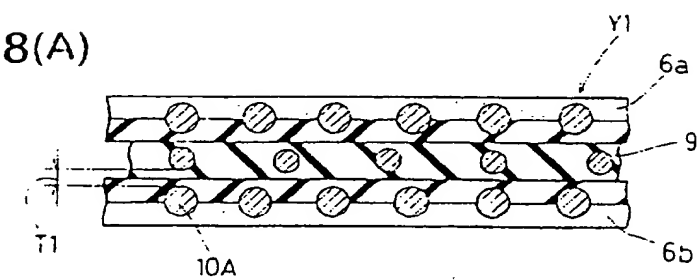


Fig.8(B)

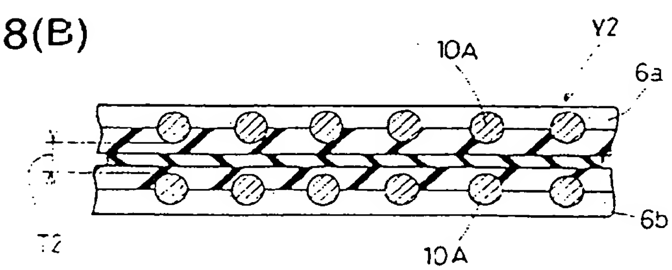


Fig.5

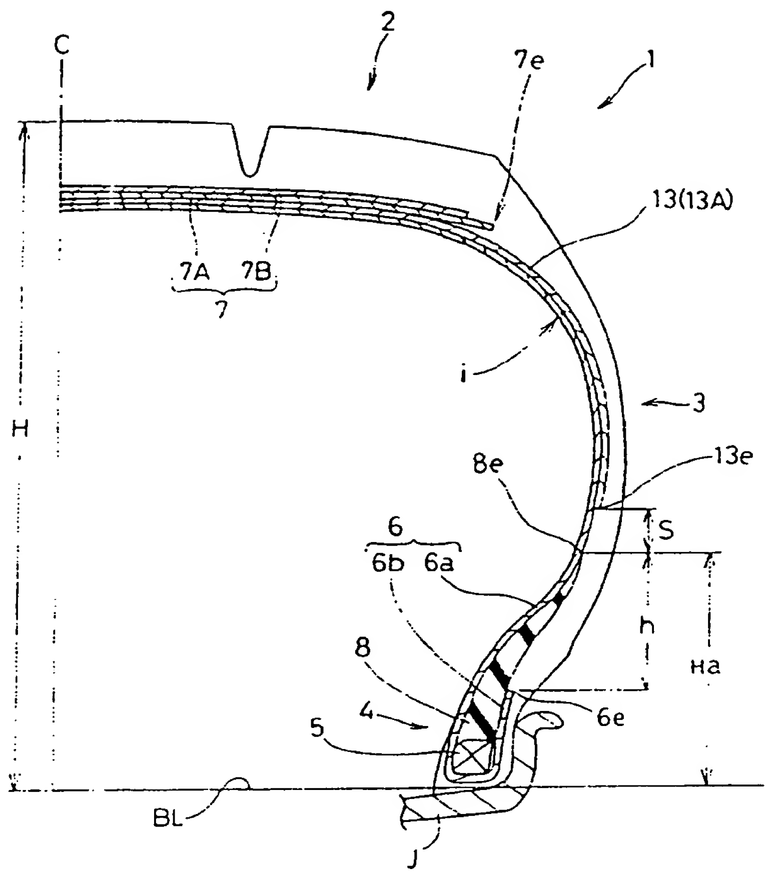


Fig.6

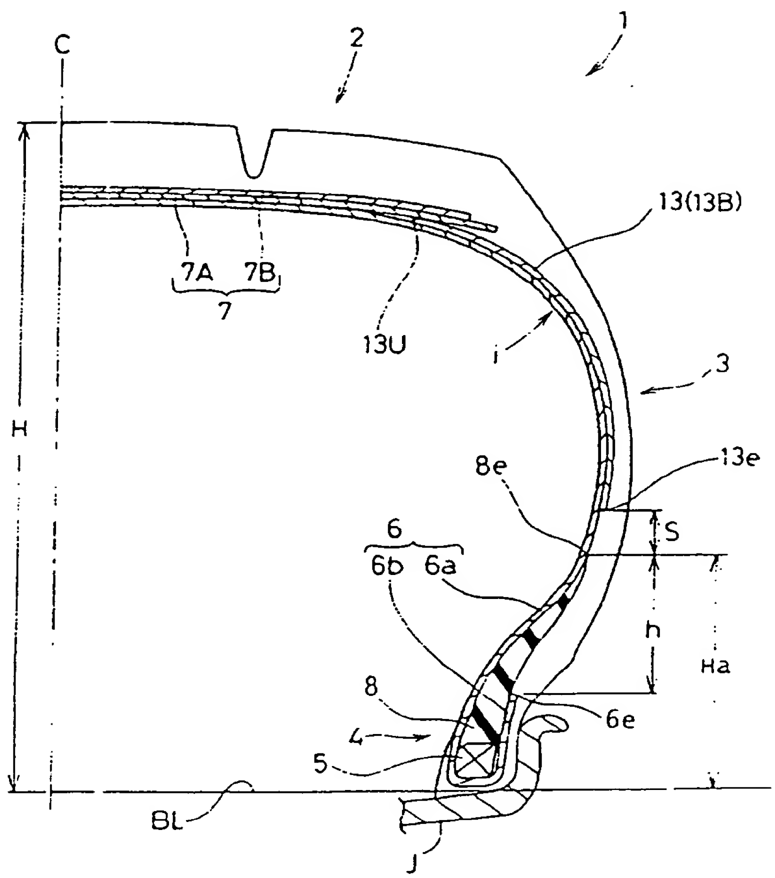


Fig.7

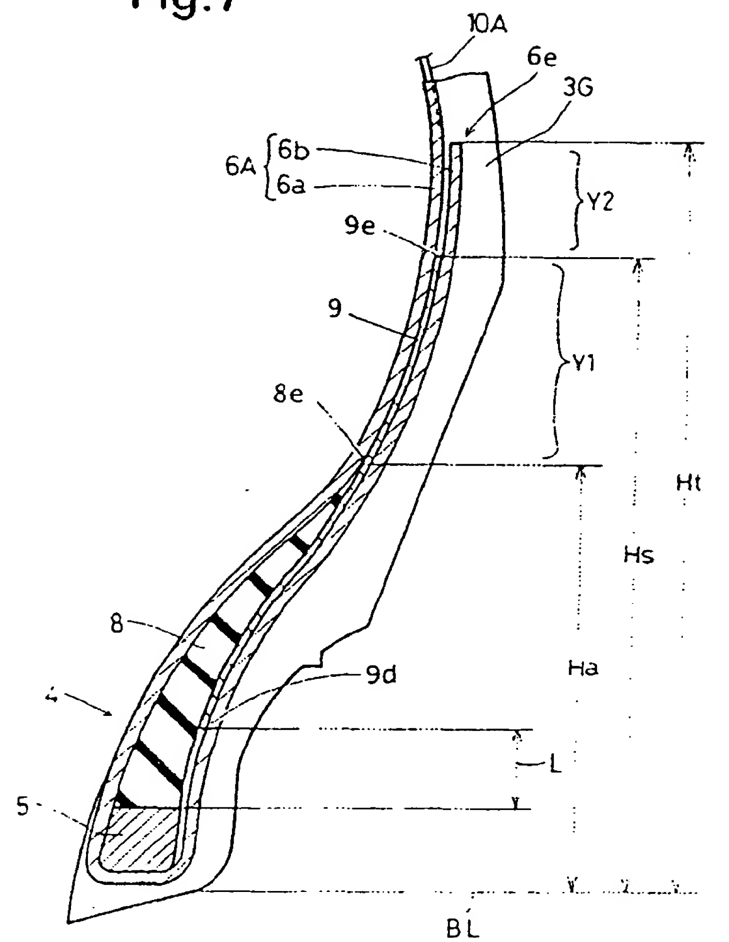


Fig.9

Prior Art